Bridge Foundation Selection

This module presents a guide for selecting suitable bridge foundation types and discusses the suitability of spread footings, Standard Plan Class piles (e.g., Alternative “V”, “W”, “X”, and “Y”), H-piles, Cast-In-Steel-Shell (CISS) piles and Cast-In-Drilled-Hole (CIDH) concrete piles.

The process for selecting a bridge foundation type is iterative and requires collaboration with Bridge Design, Structures Construction, District Design, Environmental, and other stakeholders. In addition to the geology at the site, the structure type, magnitude and types of structure loads, construction limitations, and environmental restrictions will influence selection of a suitable bridge foundation type. It is important to discuss potential foundation types with the project design team to ensure the most suitable foundation type is selected.

Investigations

The goal of the geotechnical investigation for shallow and deep foundations is to determine the properties and behaviors of the soil and/or rock, and the groundwater condition that can affect foundation design, construction, and performance. Specific investigative requirements are presented in the Shallow Foundations for Bridges, Driven Pile Foundations, and Cast-In-Drilled-Hole Pile Foundations modules.

Foundation Types

Bridge foundations consist of shallow and/or deep foundations.

Shallow Foundations

- Spread footings can be constructed on soil and rock formations that possess adequate strength and deformation characteristics.

Deep Foundations

- Driven Piles (installed with an impact hammer):
    - Standard Plan Alt “V” close-ended pipe pile (Class 90 and 140). After pile is driven to specified tip elevation and bearing, the inside of the pipe is filled with reinforced concrete.
    - Standard Plan Alt “W” open-ended pipe pile (Class 90, 140 and 200). The soil plug inside the pipe pile is not cleaned out.
    - Standard Plan Alt “X” and Alt “Y” concrete piles (Class 90, 140 and 200.
    - Steel “H” pile.

  - Cast-In-Steel-Shell (CISS) pile: After the steel shell is driven, internal soil plug is cleaned out to a specified elevation and backfilled with a seal course and reinforced concrete.

- CIDH concrete pile: CIDH concrete piles, also known as drilled shafts, can be used as smaller-diameter piles that are connected to a pile cap supporting a column or as a larger pile (typically 5 feet or larger) that directly supports a column.

  If groundwater is encountered, a slurry displacement method is used for pile concrete placement (wet method). If wet method is used, the CIDH piles must be at least 24 inches in diameter to permit Gamma-Gamma Logging (GGL) and Cross-hole Sonic Logging (CSL) tests of these CIDH piles.

Table 1 presents selection guidelines and considerations for the various bridge foundation types.

Table 1: Summary of Shallow and Deep Foundations

Foundation Type		Suitable Site Conditions	Non-suitable Site Conditions	Design/Construction Notes
Spread Footing		• Soil and rock formations • Groundwater surface elevation is below bottom footing elevation	• Soft compressible soil • Collapsible/expansive soil • Liquefiable soil • Excavation below groundwater surface elevation • Rock dipping in adverse direction	• When founded on slopes, the bearing resistance is greatly reduced • Top of footing must be below total scour elevation
Driven Pile	Standard Plan Alt “V” Pile	• Surface and near surface soil have lower bearing capacity • Good tip resistance on dense/hard soil and rock	• Cannot penetrate rock or boulders • Difficult to penetrate very dense or hard soil • Environmental/noise restrictions	• Can recommend drilling or Pre-drilling if needed to penetrate shallow very dense/hard layers • Can add driving tip/shoe • Can add a plate to Alt “W” pile tip • Can add/subtract pile length to accommodate varying subsurface conditions
	Standard Plan Alt “W” Pile	• Surface and near surface soils have lower bearing capacity		
	Standard Plan Alt “X” and Alt “Y” Concrete Pile	• Good tip resistance on dense/hard soil and rock • Requires little variance in depth to bearing layer	• Cannot penetrate rock or boulders • Difficult to penetrate very dense or hard soil • Environmental/noise restrictions	• Can recommend drilling or Pre-drilling if needed to penetrate shallow very dense/hard layers • Pile Length is limited by the trucking length, typically 60 feet for standard trailers and longer for permit trucks. • Cannot splice on additional length • Limited cut off length is 10 feet
	Steel “H” Pile	• Dense/hard soil with gravel/cobbles	• Low side resistance in saturated sands. • Environmental/noise restrictions • Cannot penetrate hard rock	• Can add driving tip/shoe for soils with cobbles/boulders • Can add pile lugs to increase tip resistance • Can add/subtract pile length to accommodate varying subsurface conditions
	CISS Pile	• Loose to very dense and soft to hard soil conditions	• Cannot penetrate hard rock and boulders • Environmental/noise restrictions • Contaminated soils (excavation of soil plug)	• GP needs to specify seal course thickness in the FR • GP need to specify dynamic monitoring control zones in the FR • Drivability study needed during design phase to determine minimum shell thickness (Request from FTI) • Contractor may need to excavate portion of soil plug during driving operation
CIDH Concrete Pile		• Can be installed in a variety of soil//rock conditions • Low levels of noise/vibration when compared to pile driving	• Potential caving in loose soils • Contaminated soils. • Artesian groundwater condition • Deep soft soils may require long piles	• Fully cased system (use of oscillator/rotator) may be used for caving soils/formations • CIDH pile length is limited to 30 times the smallest diameter of the pile • Cannot be used for battered piles • Side resistance of permanent casing is not used in the design • Side resistance of driven steel shell can be used in the design • Risk of anomalies and construction delays for repairs

Required Testing and Acceptance Criteria

The required testing and acceptance criteria for the various foundation types are presented in Table 2.

Table 2: Foundation Testing and Acceptance Criteria

Foundation Type	Required Testing/Acceptance Criteria
Spread Footing	• Footing excavation inspection if requested in the Foundation Report
Driven Pile (all types)	• Use acceptance formula in Standard Specification Section 49-2.01A(4)(c) • If the pile nominal resistance > 600 kips, or pile diameter* ≥ 18”, dynamic monitoring** is required • For pile diameter > 36”, both dynamic monitoring** and pile load test are required
CIDH Concrete Pile	• GGL/CSL for wet method concrete placement. • If tip resistance is used in design, require shaft inspection of the bottom of drilled hole

*Greatest side dimension for non-circular piles.

** FT&I provides pile bearing acceptance criteria based on results of dynamic monitoring of selected piles.